FATS FROM RHUS LAURINA AND RHUS DIVERSILOBA[1]

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(WITH ONE FIGURE)

STEVENS (12) has noticed that the green fruit of *Rhus radicans* is very poisonous. STEVENS and WARREN (13), when investigating the fruit of *R. vernix*, found the green fruit highly toxic, while the ripe fruit is harmless. WARREN (15) attributes this interesting change in toxicity to an apparent replacement of acrid resins by wholesome and palatable fats. Besides these species of *Rhus*, a fat (Japan wax) has been found in 4 species of *Rhus*: *R. succedanea* L., *R. acuminata* DC., *R. vernicifera* DC., and *R. sylvestris* Sieb. and Zucc. (6). All 6 of these species are poisonous, and it is interesting to note that the discovery of fat in the fully matured fruit of *Rhus laurina* Nutt. may add a non-poisonous species to the list.

Investigations were begun by me on the fats from *Rhus laurina* Nutt. and *R. diversiloba* T. and G. with two objects in view: (1) to discover whether or not these fats are identical with Japan wax, and (2) to determine, if possible, the connection between this fat and the poisonous property of *R. diversiloba*. This latter problem appeared all the more interesting when the fact became apparent that during the ripening of the drupes their poisonous properties simultaneously decreased with their increase in fat. When the fruits have reached full maturity (when the semi-transparent epidermis loosens and easily falls off from the waxy mesocarp) they are non-toxic. The toxicity was tested by thoroughly rubbing the pulverized fruits, as well as an alcoholic solution from them (concentrated to one-third of the original volume of the fruits), on the skin of a sensitive person.

The fats experimented with were obtained by boiling the ripe fruits in 95 per cent alcohol under a reflux condenser. The fat samples were purified by repeated solution, evaporation of the

[1] Contribution from the Rudolph Spreckel's Physiological Laboratory of the University of California.

solvent, and crystallization of the solid matter. The substances thus purified are pale yellow, hard, with a conchoidal and somewhat lustrous fracture. Their odor recalls that of tallow and beeswax. Under the microscope they appear to consist of small and large refractive grains. They are insoluble in water, slightly soluble in cold 95 per cent alcohol and ether, easily soluble in hot 95 per cent alcohol (separate on cooling to granular crystalline

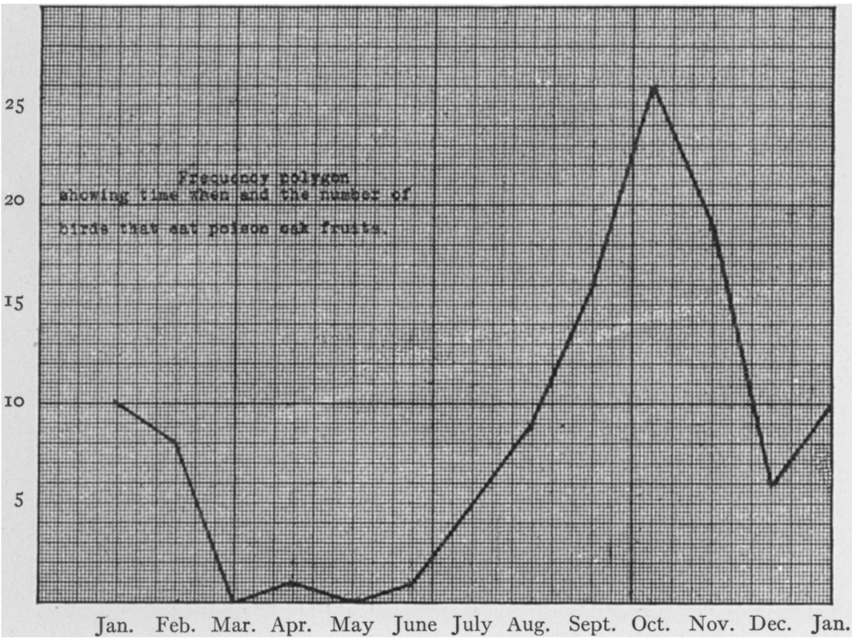

FIG. 1

mass), warm ether, benzol, petroleum ether, and carbon bisulphide. They form grease spots when melted on filter paper. That glycerol is probably a constituent is evident from an irritating odor of acrolein evolved when the substances are mixed with powdered potassium bisulphate and heated in a dry test tube.

From a consideration of their physical and chemical properties so far determined, the fats from *R. laurina* and *R. diversiloba* seem to be similar to Japan wax. This means that similar fats have been found in a non-poisonous and a poisonous species of *Rhus*.

The wide variance in the physical and chemical constants of Japan wax obtained by different experiments, and different experiments by the same investigators, may have been due to several factors, namely, adulterations of water, starch, oil of *Perilla ocimoides* Linn. (BRANNT 2), tallow (BRANNT), the fact that the fat becomes transparent below its fusing point (18–23.5° F. below m.p., BRANNT), the fact that the melting point becomes higher with the age of the sample (BRANNT), impurities, and different methods of analysis.

TABLE I

ANALYTICAL FIGURES OBTAINED

	R. diversiloba	*R. laurina*
Specific gravity...	0.9872 18°.5 C	0.8987 18°.5 C
Solubility*.......	170	136
Iodine absorption.	8.79 per cent (Hübl.)	11.44 per cent (Hübl.)
Saponi value†....	220.6	157.1
Melting point....	53° C.	74° C.

* Mg. per liter in 95 per cent alcohol at 20° C.
† Mg. KOH per gm.

Morphology of fruit of R. diversiloba in relation to fat formation

The ripe fruit of *R. diversiloba* is oval, 5–9 mm. broad, 4–6 mm. high, and 4–6 mm. thick. When first formed it has a shining grass-green color and smooth texture. When dry it becomes brown and presents long dark stripes which previously were only slightly indicated. The outer surface of these stripes is depressed because of the collapsing of the large resin ducts which lie directly beneath them. The outer layer of the fruit, which is a drupe, is something over 1 mm. thick. In the horizontal cross-section 20–30 large resin passages are present. These form a single outer row completely around, which conforms with the general outline of the drupe. Many smaller resin ducts are present, which alternate with the wider ones to form a row next to the seed. The arrangement on the top and bottom of the drupe is less regular. The epidermis is bordered by 2 or 3 layers of strong sclerenchymatous cells. Between these border layers and the resin passages lies the parenchymatous tissue whose cells for the most part contain solid fat. In

the ripe fruit the fat appears in the principal tissue of the mesocarp. Fat is not found in the exocarp, the thin walls and the inner boundary of the mesocarp, the sclerenchymatous cells, the cells of the vascular bundles and their sheaths, and the parenchymatous sheaths of the resin passages.

The presence of solid fat in the fruit cannot be detected before July. At the beginning of August fat formation is nearly completed. The granulated layer of fat can be seen in the cell between the membrane and the protoplasm. This layer makes the lumen smaller, increases on the outside, and goes in between the already formed fat. Its granular form changes to striated masses. Before the formation of this fat in the fruit a progressive increase in the starch content is noticeable. Starch forms partly in the chromatophores in the cell and partly in the cells. When the fruit cells are rich in starch the cells contain besides only granular protoplasm and nuclei. This starch gives a positive reaction with iodine. When fat formation is near completion no starch can be detected in the fruit. In fruits which have nearly completed their growth the resin passages are everywhere constricted by the growth of parenchyma sheaths. From a consideration of these phenomena fat is apparently formed from starch and not from the resin-like poisonous sap.

This view does not seem untenable, for it has been proved that in the storage foods of plants carbohydrates and fats are interchangeable, and in certain cases carbohydrates are entirely replaced by fats. Starch is stored in potatoes and in the tubers of dahlia, and cane-sugar is stored in beet root; the seeds of the two former plants contain oil, while those of the beet are starchy. Although the grains of most grasses contain starch, some instances are known in which fatty oil is present instead (*Phragmites communis*, *Koeleria cristata*, etc.). In the cotyledons of *Impatiens Balsamina* amyloid is stored in the form of enormously thickened walls, while in other species of *Impatiens* the tissue of the cotyledon is thin-walled and oil is present instead of reserve cellulose.

The change of carbohydrates to fats in the seeds of plants has been studied by SCHMIDT (11), LECLERC DU SABLON (4), and others. These investigators have shown clearly that as the

carbohydrates decrease in seeds the fat increases. For instance, when almond seeds first begin to ripen, they are rich in carbohydrates and poor in fats; when fully matured, however, they are poor in carbohydrates and rich in fat. The seeds of *Ricinus* and *Paeonia* are also typical cases. It seems as though the oil in the mature *Ricinus* seed comes from glucose, while that of the *Paeonia* is formed from starch. As it is possible for the plant to translocate fat as such, provided it be an emulsion sufficiently fine, or in the form of fatty acids and glycerine, it might appear to some that the fats in seeds have not been formed *in situ*, but have been conveyed there by the sap. It cannot be denied that translocation of fat may occur to a certain extent; but it is a fact that fats will appear as the carbohydrates disappear in immature seeds even when removed from the parent plant. This fact, when considered with the facts known regarding the formation of fats in vegetative organs under the influence of cold, leads to the inevitable conclusion that fats are formed at the expense of carbohydrates and that this transformation may occur *in situ*.

SCHMIDT (11) and LECLERC DU SABLON (4) have shown conclusively that during the germination of oily seeds a reversal of this process takes place, carbohydrates being formed apparently from fat.

The processes by which carbohydrates are changed to fat are still unknown. As the carbohydrates do not contain such complicated carbon chains as the fats, the formation of fat from carbohydrates must consist of a synthesis, in which the CHOH group is converted into CH_2; hence a reduction must occur.

The formation of fat from carbohydrates in the plant has its parallel in the animal. The great influence of carbohydrates on fat formation in the animal was observed and proved by LAWES and GILBERT (5), VOIT (14), LUMMERT (7), and many others by means of a series of nutrition experiments with different animals, with foods especially rich in carbohydrates, who have apparently proved that a direct formation of fat from carbohydrates does actually occur.

The fat of the poison oak fruit is not a reserve food supply for use of the cotyledon; this is shown by morphology and sprouting.

When the drupe is planted, the growing embryo does not utilize the fat, as it remains unchanged. The fat, however, may be of service to the seed as a protection against cold on account of its low power for heat conduction, increasing its chance of dispersal by streams, as it is far lighter than starch (specific gravity of starch 1.56, fat 0.9872); as a protection from rain and humidity; as a protection from fungi (PFEFFER **9**); and as an attraction to birds and therefore a factor in seed dissemination. The ripe fruits persist on the plant during the winter, long after the leaves have fallen, some until May. Birds, therefore, can see them for a long distance. When eaten, the fatty covering of the drupe only is digested; the ejected seeds can still germinate. MÖBIUS (**8**) has observed the fruits of *R. vernicifera* eaten by half-wild pigeons at Frankfurt. REINECKE (**10**) has recorded the doves of Samoa as eating the fruit of *R. tahitensis*. BARROWS (**1**) speaks of the consumption of the fruit of *R. venenata* and *R. Toxicodendron* by the crow. After eating the fruits the crow rapidly digests the nutritious pulp and ejects from the mouth (in less than 40 minutes after eating) the seeds clean and devoid of pulp, together with the sand swallowed to aid in digestion. Of these ejected seeds 90 per cent germinated.

BRYANT (**3**) has observed that the favorite food of the roadrunner (*Geococcyx californianus*) during the winter season consists of the fruit and seeds of *R. integrifolia*. Unlike many birds which turn their attention to vegetable food during the winter season, the roadrunner appears to discriminate as to the kind of seeds taken. Of the stomachs examined, those of 26 (31.3 per cent) contained the seeds or fruit of *R. integrifolia*, and 8.4 per cent of the food taken by all the birds was made up of this element. The attention of the roadrunner is apparently attracted to this vegetable food only during the winter season, when insects, lizards, and other kinds of food are least abundant.

Summary

1. Substances more similar to Japan wax than to any other fat have been isolated from the ripe fruit of *R. laurina* and *R. diversiloba*.

2. A decrease in the poisonous properties of the fruit of *R. diversiloba* occurs simultaneously with the increase in fat content.

3. The decrease in the poisonous properties in the ripening of the fruit of *R. diversiloba* eventually results in the fruit becoming non-toxic. This phenomenon is not necessarily due to a chemical transformation of the poison into fat for: (a) subsequent to the formation of fat the cells in which it is deposited become filled with starch; (b) it is possible for the plant to transform starch into fat; (c) fat is not formed in the parenchymatous sheaths of the resin passages; (d) consequent upon the formation of fat, the resin passages are everywhere constricted by the growth of parenchyma sheaths; (e) a similar fat has been found in the fruit of a non-poisonous species of *Rhus*.

I am indebted to Professor T. BRAILSFORD ROBERTSON for having placed the resources of his laboratory at my disposal during this investigation.

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